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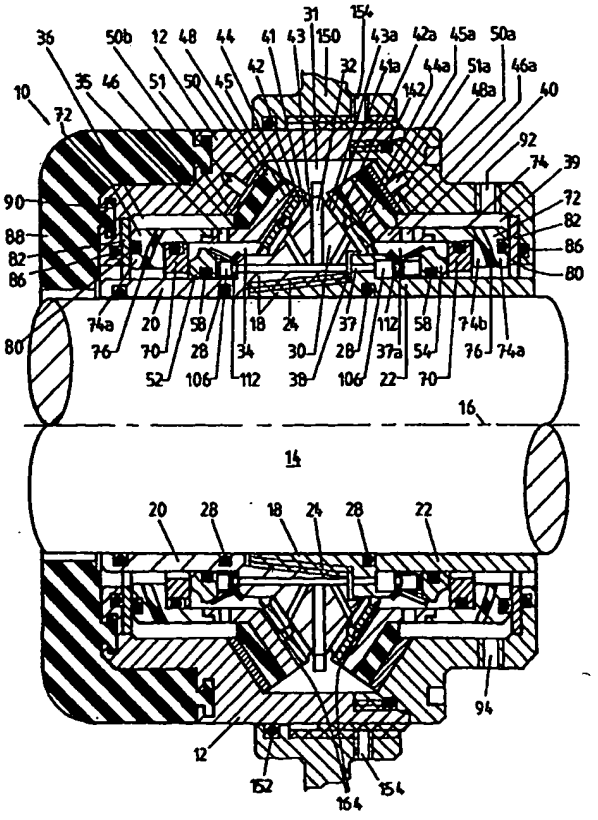
**Published**
*With international search report.*

(54) Title: A SEAL APPARATUS

(57) Abstract

A seal apparatus (10) is arranged to seal a rotatable shaft (14) (e.g. a propeller shaft of a marine craft or the impeller shaft of a centrifugal slurry pump). A two–part metal sleeve (20, 22) turns with the shaft. It has a radial extension (30) the angled faces (41, 41a) of which abut annular bronze bearings (42, 42a). A pair of mechanical seal members (52, 54) rotate with the sleeve and engage with non–rotary seal members (70) mounted on cushion members (72). This pair of cushion members is designed principally to absorb tilting movements of the shaft (14). These movements are absorbed by annular rubber members (76) sandwiched between pairs of metal parts (74a, b). Rubber shock absorbers (48, 48a) are also provided to absorb lateral, and some tilting, movement of the shaft.



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## TITLE

"A SEAL APPARATUS"

## BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to a seal.

## SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided a seal apparatus for providing a seal between an axially rotatable shaft having a longitudinal axis and a housing, which includes a sleeve mounted within a stationary casing, the sleeve being disposed, in use, in contiguous relation to the shaft and being arranged for rotation with the shaft, at least one annular cushion member being provided with two parts separated by a curved resilient member extending away from the shaft such that the parts can move laterally and angularly relative to one another about the resilient member to accommodate angular twisting of the shaft.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a cross sectional view of a seal in accordance with the present invention;

Figure 2 is a cross sectional view of a first part of a casing of the seal of Figure 1;

Figure 2a is a cross sectional view to an enlarged scale of the first part of the casing of Figure 2;

Figure 3 is a cross sectional view of a second part of the casing of the seal of Figure 1;

Figure 4 is a cross sectional view of an annular mechanical sealing member of the seal of Figure 1;

Figure 4a is a cross sectional view to an enlarged scale of part of the annular mechanical sealing member of Figure 4;

Figure 4b is a front elevation of part of the annular mechanical sealing member of Figure 4;

Figure 5 is a front elevation of part of an annular spring washer of the seal of Figure 1;

Figure 5a is a side elevation of the annular spring washer of Figure 5;

Figure 6 is a side elevation of an annular engagement member of the seal of Figure 1;

Figure 6a is a front elevation of part of the annular engagement member of Figure 6;

Figure 7 is a cross-sectional view of a first part of a sleeve of the seal of Figure 1;

Figure 7a is a front elevation of part of the first part of the sleeve shown in Figure 7;

Figure 7b is a rear elevation of part of the first part of the sleeve shown in Figure 7;

Figure 8 is a cross-sectional view of a second part of the sleeve of Figure 1;

Figure 9 is a cross sectional view of a shock absorber assembly of the seal of Figure 1;

Figure 9a is a front elevation of part of the bearing assembly of Figure 9;

Figure 10 is a cross sectional view of a bearing assembly of the apparatus of Figure 1; and

Figure 11 is a cross sectional view of a body used to accommodate angular movement of a shaft.

## DESCRIPTION OF THE INVENTION

In Figure 1 of the accompanying drawings there is shown an apparatus 10 for providing a seal between a stationary case 12 and a rotatable shaft 14. The case 12 is formed in two parts as will be described hereinafter.

The shaft 14 is an elongated cylindrical member with a longitudinal axis 16 which is arranged to be rotated longitudinally relative to the case 12. In addition to the

longitudinal rotational movement the shaft 14 can also move inadvertently, transversely or angularly relative to the case 12.

A sleeve 18 is mounted on the shaft 14 and is arranged to rotate therewith. The sleeve 18 includes a first annular component 20 which extends around the shaft 14 and preferably is formed of a relatively hard material such as stainless steel. The sleeve 18 also includes a second annular component 22 which is also disposed around the shaft 14 . The component 22 is preferably formed of a relatively soft material such as a soft metal, to grip around the shaft 14 better. The component 22 may be keyed to the shaft 14 for secure mounting. The components 20 and 22 are illustrated in Figures 7, 7a, 7b and 8.

The annular components 20 and 22 are preferably interconnected by a taper lock 24 in known manner.

Further, inner faces of the components 20 and 22 are provided with circumferential grooves containing O ring seals 28 so as to provide a sealing engagement between the shaft 14 and the sleeve 18.

Further, as can be seen in Figure 7, the annular component 20 also has a rearward extension 30 which, as shown, is triangular in cross section. Further, the extension 30 includes lubricating galleries 32 which enable lubricating fluid to be fed into the apparatus 10 at a pressure greater than the pressure being sealed against. As can be seen in Figures 7a and 7b the extension 30 has a castellated periphery 33 located in a cavity 31. The castellated portion 33 enables a tool to hold the apparatus during assembly to tighten up the apparatus and also to agitate lubricating fluid in the cavity 31, in use.

The lubricating galleries 32 in the extension 30 are fluidly connected to lubricating galleries 34 adjacent the sleeve 18. Further, the lubricating galleries 34 are connected

through a port 35 to a further lubricating gallery 36. As can be seen in Figure 1, when the taper lock 24 is fully engaged there is a gap 38 between the member 20 and the member 22. Also, the lubricating galleries 32 are connected to additional lubricating galleries 37 and 37a. Thus, lubricant can flow across the gap 38 into the gallery 37 or along the gap 38 into the gallery 37a. The lubricating gallery 37a is connected to a further lubricating gallery 39 through a port 40.

The extension 30 has rearward faces 41 and 41a which are disposed at an acute angle to the longitudinal axis 16 such as an angle of, from about 45° to 75°, preferably about 60°. Abutting the faces 41 and 41a are respective annular bearings 42 and 42a which, as shown, are disposed parallel to the faces 41 and 41a and are therefore disposed at the same angle to the axis 16. The bearings 42 and 42a are typically plain, bronze bearings. As shown a respective gallery 32 leads to an inner face 43 and 43a of each bearing 42 and 42a respectively.

Further, each bearing 42 and 42a has an outer face 44 and 44a respectively. Annular spacer components 45 and 45a are abutted with the outer faces 44 and 44a respectively. Further, the components 45 and 45a have inner longitudinal extensions 46 and 46a respectively which have stopper ends and which are disposed parallel to the axis 16. The components 45 and 45a may be made of steel.

Annular shock absorbers 48 and 48a are mounted about the spacer components 45 and 45a respectively. The shock absorbers 48 and 48a are formed of resilient material such as rubber. The shock absorbers 48 and 48a are bonded to the spacer components 45 and 45a respectively and thus prevent the spacer components 45 and 45a from rotating with the shaft 14.

Further, annular members 50 and 50a are disposed about and externally of the shock absorbers 48 and 48a. The annular members 50 and 50a are also typically formed of steel, and are also bonded to the shock absorbers 48 and 48a respectively. The annular members 50 and 50a are preferably positively secured to the stationary case 12 by means of a respective key or dowel 51 and 51a.

The shock absorber assembly is illustrated in Figure 9. As shown in Figure 9 the annular members 50 contains a groove 50b for easy engagement with the dowel 51. A similar groove 50b is found in the annular member 50a.

The bearing assembly is illustrated in Figure 10. In Figure 10 it can be seen that there is a lubrication gallery 160 along an inner face of the bearing 42, a lubricant conduit 162 through the bearing 42. Also, as can be seen in Figure 1, there is a lubricating gallery 164 along an outer face of the bearing 42.

Further, a first floating annular mechanical sealing member 52 is disposed about the member 20 whilst a second floating annular mechanical sealing member 54 is disposed about the member 22. Each sealing member 52 and 54 is provided with a circumferential groove containing an O ring seal 58 which establishes a seal between the sleeve 18 and the sealing member 52 and 54.

Further, as can be seen in Figure 4, the sealing member 52 has a periphery 100 which is formed with a plurality of spaced recesses 102 as can best be seen in Figure 4b. Each recess 102 has a base 104, which slopes inwardly towards the extension 30 as can best be seen in Figure 4a. The sealing member 54 has a similar construction.

Further, a respective annular spring washer 106 is disposed about the sleeve 18 adjacent a seal 52 or 54. The washers 106 are illustrated in Figures 5 and 5a. As can be seen in Figure 5a, each washer 106 contains alternating circumferentially extending portions

108 interconnected by axially extending portions 110 such that a first series of circumferential portions 108 are disposed in a first plane and a second interdigited series of circumferential portions 108 are disposed in a second plane spaced from but parallel to the first plane.

Further, annular engagement members 112 are disposed between the washers 106 and the sleeve 18. As can be seen in Figures 6 and 6a the engagement members 112 include a flat ring 114 having a first series of spaced annular lugs 116 projecting from a first side thereof and a second series of spaced annular lugs 118 projecting from a second, opposite side thereof.

The lugs 116 are relatively long compared to the lugs 118 and are arranged to bridge over the adjacent washers 106 and engage with respective apertures 102 in the sealing members 52 and 54. Further, the lugs 118 are arranged to engage with spaced recesses 119 in a face of the sleeve 18 as shown in Figure 7b. In this way, the sealing members 52 and 54 are positively engaged with the sleeve 18 and are constrained to rotate in unison with the sleeve 18.

Thus, the sealing members 52 and 54 are arranged for rotational movement with the members 20 and 22. Further, they are in engagement with stationary mechanical sealing members 70.

The sealing members 70 are mounted to stationary annular cushion members 72. Each cushion member 72 includes a metallic body 74 typically formed of steel. Further, the body 74 is divided into two parts 74a and 74b by an annular resilient member 76 which may be formed of rubber. It can be seen that each resilient member 76 is curved longitudinally of the shaft 14 and extends along part of the radius of a circle. A portion of each resilient member 76 adjacent the shaft 14 is disposed outwardly of an end

thereof remote from the shaft 14. In this way, as will be described further hereinafter, the parts 74a and 74b are able to move relative to one another about a resilient member 76 along a curve to accommodate angular twisting movement of the shaft 14. The bodies 74 are disposed between the stationary case 12 and the mechanical sealing members 70.

Further, an annular recess is formed in outer faces of each of the bodies 74 and a respective O-Ring Seal 80 is located in each of these annular recesses. Still, further, an outer face of each body 74 abuts an annular thrust washer 82 which is disposed between the respective body 74 and the stationary case 12. The stationary case 12 contains annular recesses which contain O ring seals 86 for sealing engagement with the thrust washers 82.

Also as can be seen in Figure 11, each part 74b includes an annular extension 75 which has a stepped end which engages positively as a press bit with the stepped end of one of the extensions 46 and 46a discussed hereinabove.

In addition, a wear plate 88 is mounted to the stationary case 12 on a side of the apparatus 10 facing a chamber which is to be sealed such as a chamber containing an abrasive slurry. The wear plate 88 is removably connected to the case 12 by means of T-shaped coupling members 90.

Further, the case 12 contains a lubricating fluid inlet 92 and a lubricating fluid outlet 94.

As can be seen in Figures 2, 2a and 3, the case 12 is formed in two parts. A first part 130 is shown in Figures 2 and 2a whilst a second part 132 is shown in Figure 3. The part 130 has a threaded insert 134 adjacent one end thereof whilst the part 132 has a threaded collar 136 adjacent one end thereof. The parts 130 and 132 are arranged to be

interengaged by threaded engagement of the threaded members 134 and 136 as can be seen in Figure 1. The part 130 has an outwardly projecting annular flange 137. Further, the part 132 has an outwardly projecting annular rib 138 located inwardly of the collar 136 and adjacent an annular recess 140. In the assembled condition as shown in Figure 1 the lug 138 abuts the threaded members 134 and 136. Further, an O-ring seal 142 located in the recess 140 engages sealingly with the flange 137.

Disposed around the case 12 of the apparatus 10 is an annular flange member 150 arranged to connect the apparatus 10 to a member such as a wall of a tank in known manner. The flange member 150 is threadedly engaged with an outer threaded portion of the case 12. Further, an O ring seal 152 is provided to give sealing engagement between the case 12 and the flange member 150. The flange member 150 enables the apparatus 10 to be adjusted in position on the engaged threads. In this way air impeller and the like can be brought closer to the apparatus 10 to reduce cavitation. Once the position of the apparatus 10 has been determined it may be retained in place in the flange 150 by means of grub screws disposed in aperture 154.

In use, the apparatus 10 is mounted in an aperture of a member such as the housing of an industrial centrifugal slurry pump into which the rotatable shaft 14 extends to drive an impeller. However, the seal of the present invention has a wide variety of applications. For example, it can be used as a sealing system for a propeller shaft of a marine craft.

Thus, in use, the shaft 14 rotates axially. However, in addition to the desired axial rotation there is also a tendency for the shaft 14 to move laterally and also to twist angularly. The lateral movement is accommodated by the shock absorbers 48 and 48a and the resilient member 76 being compressed on one side or the other of the shaft 14.

Angular movement is accommodated by the parts 74a and 74b of the body 74 and also the shock absorbers 48 and 48a. The parts 74a and 74b are rotated relative to one another about the respective resilient member 76. The spring washer 106 remains at a constant preset tension regardless of shaft twisting or vibration. Further, the component 74a in each case abuts against the adjacent thrust washer 82. Therefore, the part 74b is able to move angularly relative to the part 74a about the member 76. Also, the disposition of the shock absorbers 48 and 48a at an acute angle to the shaft 14 means that some of the twisting movement is accommodated by the shock absorbers 48 and 48a. The shock absorbers 48 and 48a and the resilient members 76 compress or stretch to compensate for angular twisting of the shaft 14 and stretch or compress equally for lateral movement.

The resilient member 76 allows each part 74a to move laterally by a relatively small amount whilst the part 74b is able to move in a more pronounced manner and arcuately as well as laterally. This ability of the parts 74a and 74b to move relative to one another and then about the resilient member 76 compensates for the angular movement of the shaft 14 and prevents jamming of the shaft 14.

Also, the sleeve 18 in its entirety rotates with the shaft 14 within the bearings 42 and 42a. The spacer members 45 and 45a are constrained from rotational movement by being bonded to the shock absorbers 48 and 48a. Further, the spacer members 50 and 50a are additionally constrained from movement by means of the keys 51 and 51a to the casing 12.

In operation of the seal 10, lateral movement of the shaft 14 will cause instantaneous corresponding lateral movement of the sleeve 18 and therefore instantaneous corresponding lateral movement of the stationary components against the shock

absorbers 48 and 48a and also in part against the resilient member 76. When the shaft 14 moves angularly a similar transmission of movement occurs except that this is a corresponding relative angular movement in this case.

Further, the lubricating fluid is, in use, pumped under pressure into the seal through the inlet 92 and extends to the cavity 31 and all of the galleries 32, 34, 35, 36, 37, 37a, 38, 39 and 40 before exiting via the outlet 94. In particular, lubricating fluid flows from the galleries 32 along the galleries 160 and the galleries 164 to the galleries 36 or 39. Also, lubricating fluid flows from the galleries 32 through apertures 166 in the engagement members 112 (see Figure 6a) to the washer 106 and then into the chambers 34 and 37.

Lubricating fluid is pumped in at a pressure that is always greater than delivery pressure. This ensures that the seal faces always run in a clean environment. If a temporary instantaneous parting of faces occurs, slurry is repelled from the interior of the apparatus 10 by the greater pressure of the lubricating fluid ensuring that the apparatus 10 does not fail.

Modifications and variations such as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

## CLAIMS

1. A seal apparatus for providing a seal between an axially rotatable shaft having a longitudinal axis and a housing, characterised in that it includes a sleeve mounted within a stationary casing, the sleeve being disposed, in use, in contiguous relation to the shaft and being arranged for rotation with the shaft, at least one annular cushion member being provided with two parts separated by a curved resilient member extending away from the shaft such that the parts can move laterally and angularly relative to one another about the resilient member to accommodate angular twisting of the shaft.

2. A seal apparatus according to claim 1, characterised in that the sleeve is formed in two parts which are interconnected by a taper lock.

3. A seal apparatus according to claim 1 or 2, characterised in that the sleeve includes a rearward extension having sides disposed to the shaft at an acute angle.

4. A seal apparatus according to claim 3, characterised in that a bearing assembly is mounted adjacent to each side of the rearward extension.

5. A seal apparatus according to claim 4, characterised in that a shock absorber assembly is mounted adjacent to the bearing assembly on a side thereof remote from the rearward extension.

6. A seal apparatus according to any one of the preceding claims, characterised in that there is provided at least one rotary mechanical sealing member which is positively engaged with the sleeve for rotation therewith.

7. A seal apparatus according to claim 6, characterised in that a respective stationary mechanical sealing member mounted to the annular cushion member engages with the or each annular rotary mechanical sealing member.

8. A seal apparatus according to claim 7, characterised in that the sleeve is arranged for instantaneous lateral and angular movement corresponding to movement of the shaft such that the stationary mechanical seal member and the rotary mechanical seal member move in unison with the sleeve.

9. A seal apparatus according to claim 7 or 8, characterised in that the or each rotary mechanical seal member is spring urged into engagement with the respective stationary mechanical and sealing member under a substantially constant preload.

10. A seal apparatus according to any one of the preceding claims, characterised in that the seal apparatus includes a plurality of lubricating galleries extending from a lubricating fluid inlet to a lubricating fluid outlet.

11. A seal apparatus according to any one of the preceding claims, characterised in that the annular cushion member includes a first outer part and a second inner part, the first outer part being disposed between the stationary casing and the curved resilient

member, the second inner part being disposed between the sleeve and the curved resilient member, such that the first outer part is arranged for relatively small lateral movement whilst the second inner part is arranged for relatively large lateral and angular movement.

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12. A seal apparatus according to any one of the preceding claims, characterised in that the seal apparatus is arranged to be mounted in such a way that the seal apparatus is able to be moved, in use, along the shaft towards an operative device to reduce cavitation.

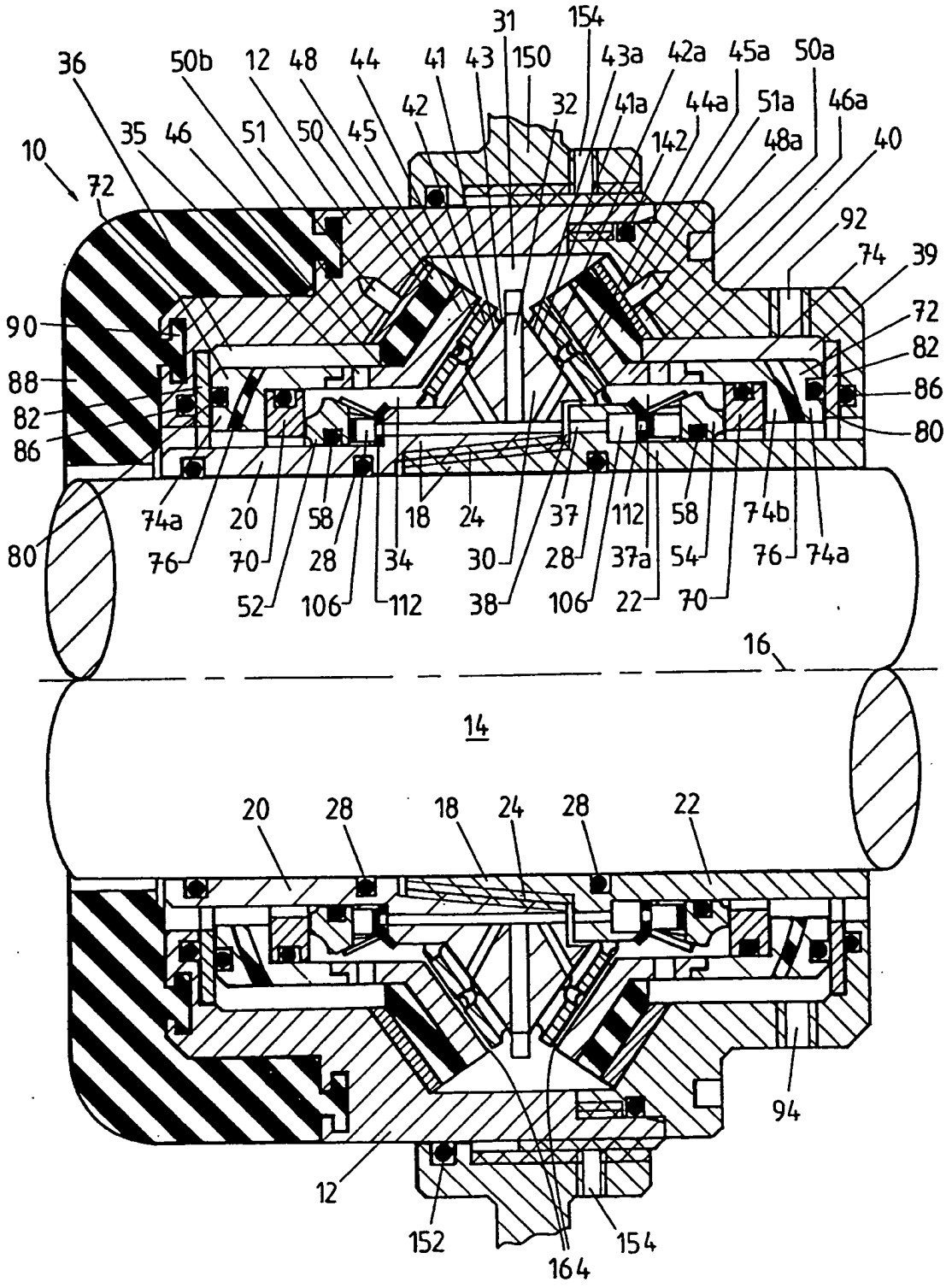
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FIG.1

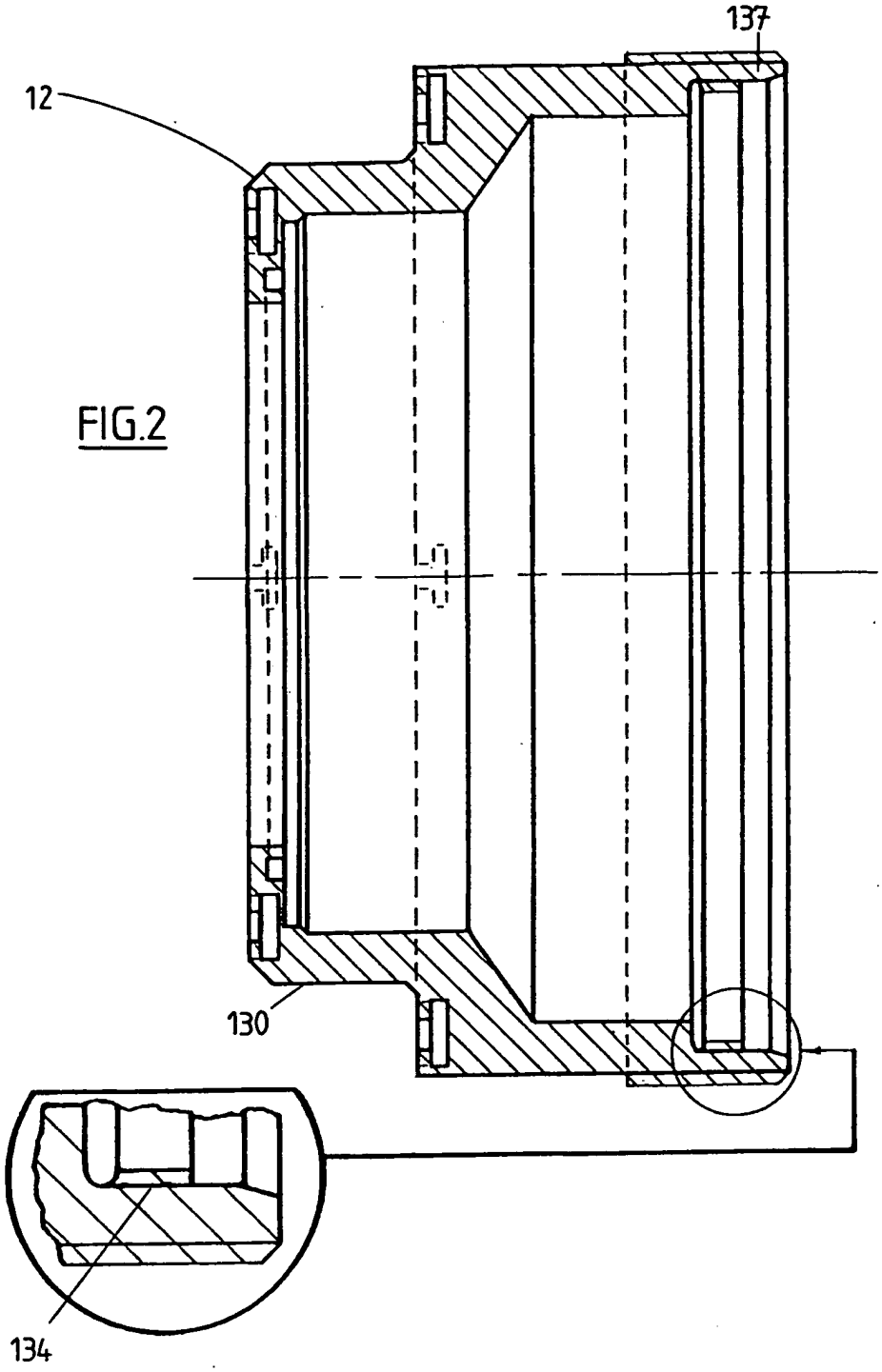



FIG.2

FIG 2a

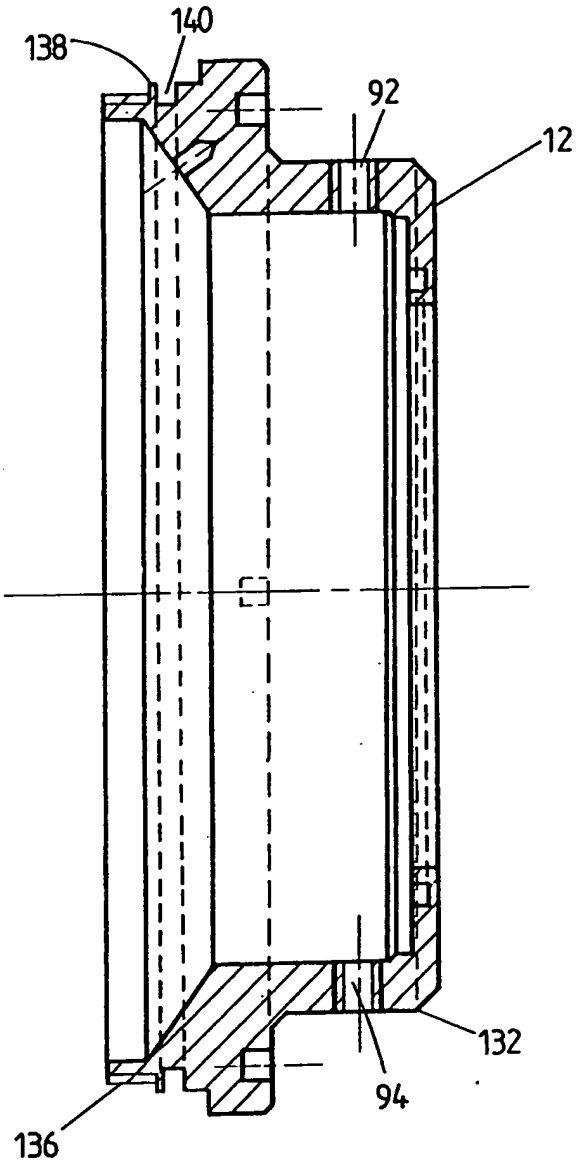
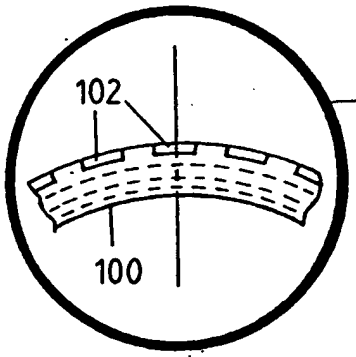



FIG.3

FIG.4b



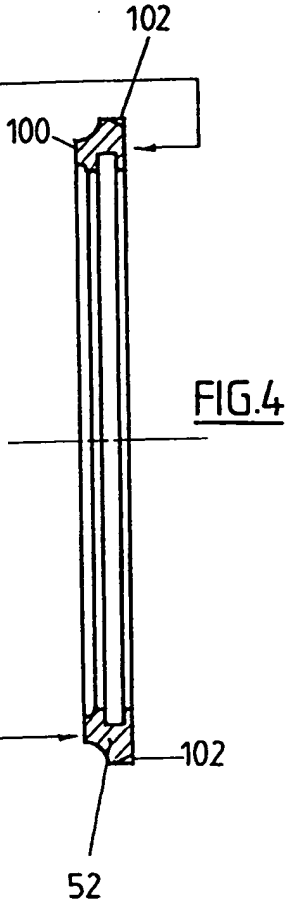
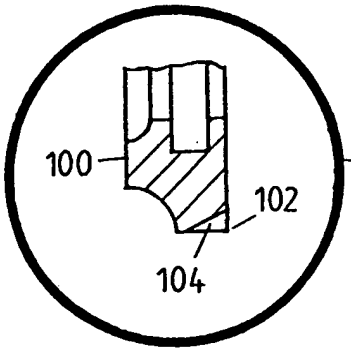




FIG.4

FIG.4a



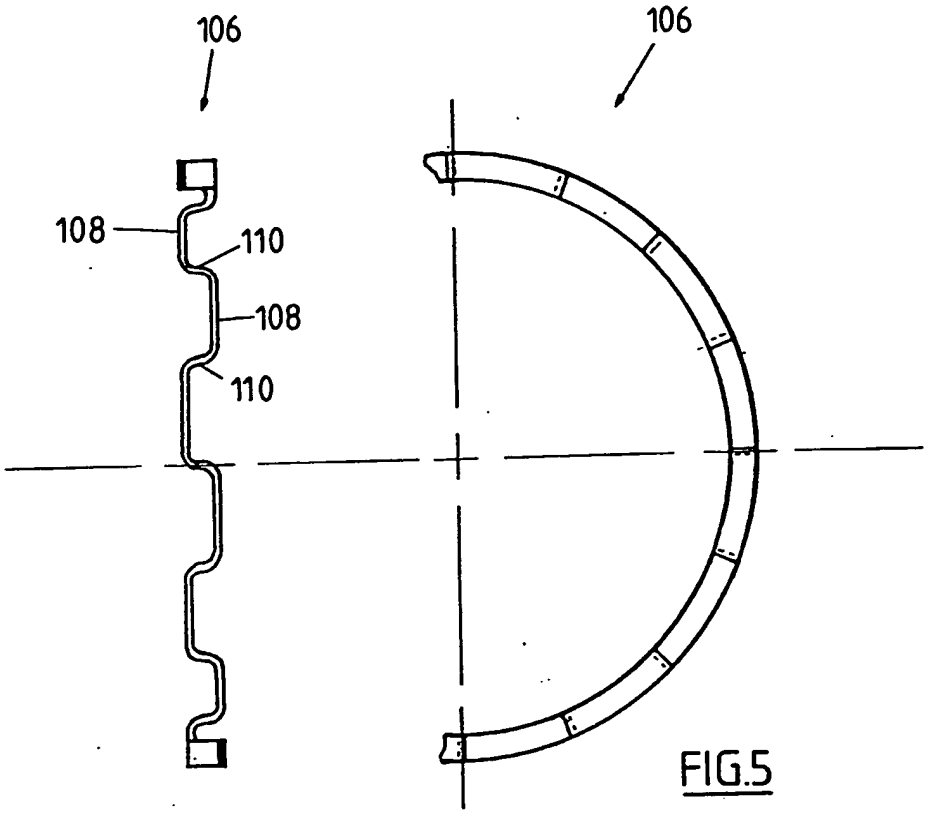



FIG.5a

FIG.5

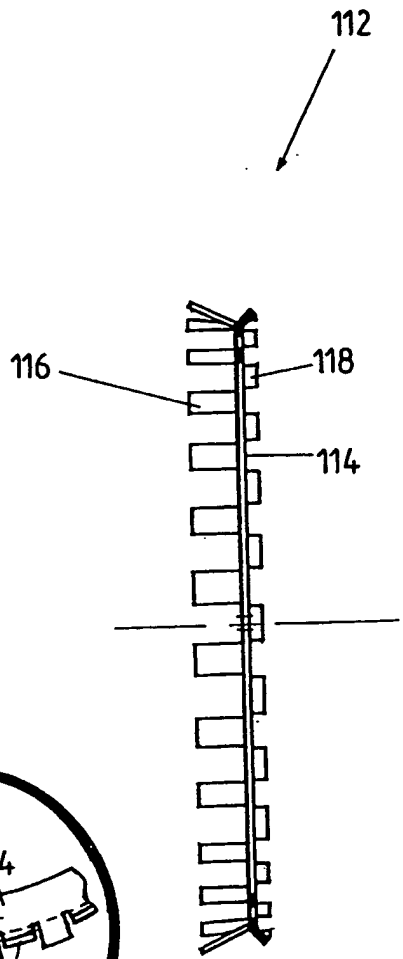
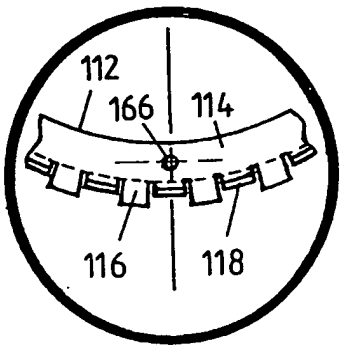



FIG.6

FIG.6a



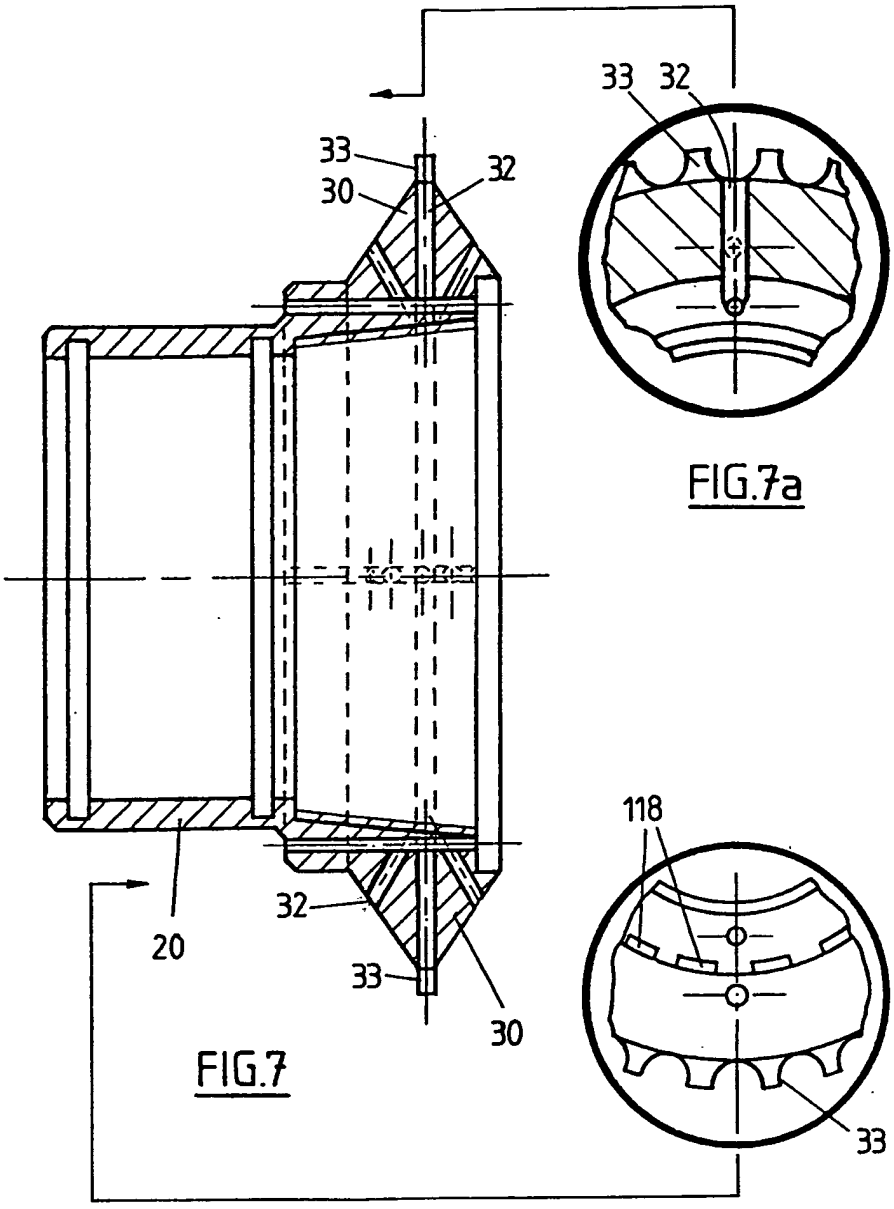



FIG.7

FIG.7a

FIG.7b

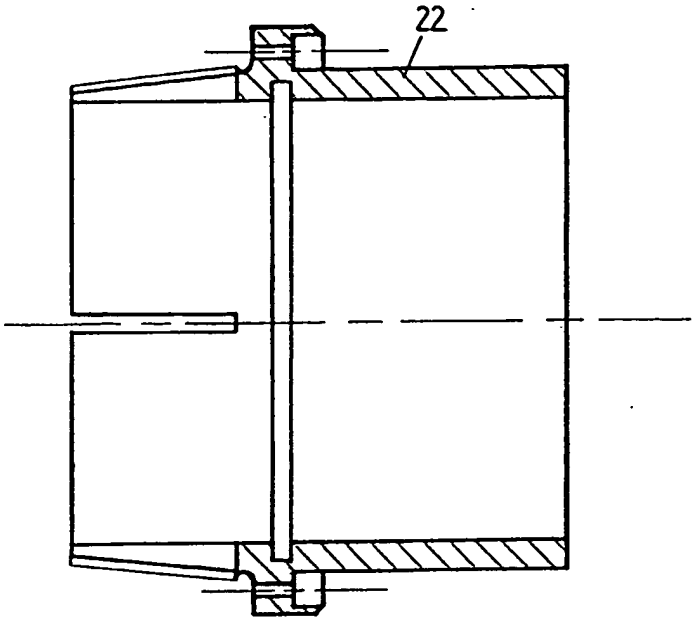



FIG.8

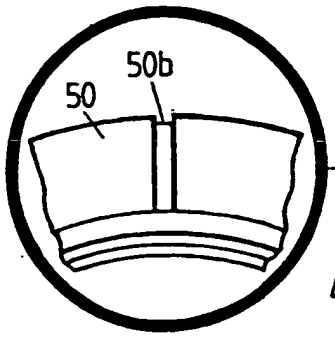



FIG.9a

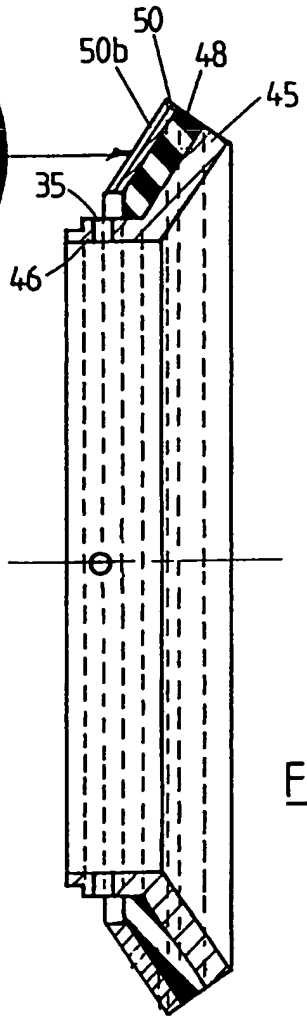



FIG.9

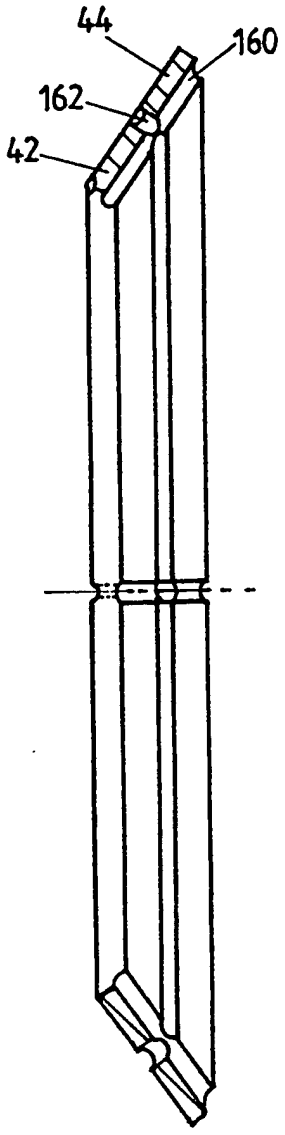



FIG.10

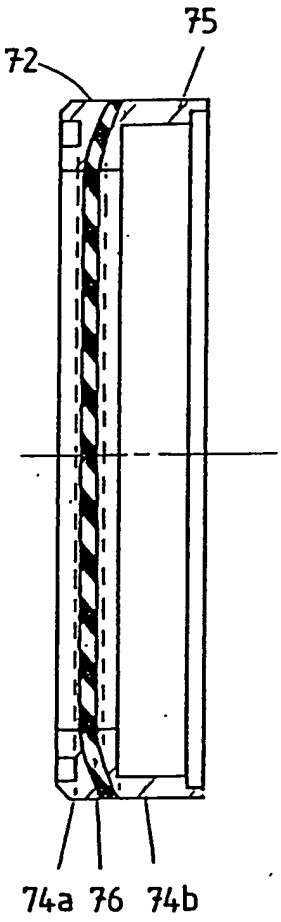



FIG.11

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 98/00840

**A. CLASSIFICATION OF SUBJECT MATTER**

Int Cl[6]: F16J 15/54, 15/34

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
F16J 15/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: (F16C OR F16J) AND SEAL: AND (MISALIGN: OR ALIGN: OR ECCENTRIC: OR EXCENTRIC: OR OFF SET OR OFF CENT: OR TWIST: OR SKEW: etc.) AND SHAFT# AND ROTA:

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | GB 2182730 A (J. H. FENNER & COMPANY LIMITED) 20 May 1987 | |
| A | DE 3520180 A (SEIBERT) 13 March 1986 | |
| A | US 5590966 A (CHERNY) 7 January 1997 | |

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 16 November 1998 | 24 NOV 1998 |
| Name and mailing address of the ISA/AU<br>AUSTRALIAN PATENT OFFICE<br>PO BOX 200<br>WODEN ACT 2606<br>AUSTRALIA<br>Facsimile No.: (02) 6285 3929 | Authorized officer<br><br>IAN KILBEY<br>Telephone No.: (02) 6283 2115 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 98/00840

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 2628112 A (HEBARD) 10 February 1953 | |
| A | US 2793087 A (HAYES) 21 May 1957 | |

# INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
**PCT/AU 98/00840**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| US | 5590966 | AU | 62796/94 | CA | 2158169 | CN | 1122628 |
| | | EP | 699281 | WO | 9421944 | | |

END OF ANNEX